Source: Schleser G, Winiger M, Bräuning A, Gärtner H, Helle G, Jansma E, Neuwirth B, Treydte K (eds.) (2003) TRACE - Tree Rings in Archaeology, Climatology and Ecology, Vol. 1: Proceedings of the DENDROSYMPOSIUM 2002, April 11th - 13th 2002, Bonn / Jülich, Germany. Schriften des Forschungszentrums Jülich, Reihe Umwelt Vol. 33, p. 28 - 34.

A detailed view on instrumental temperature data from northern Eurasia

U. Büntgen[1], D. Frank[2] and J. Esper[3]

[1] *Department of Geography, University of Bonn, Germany ; e-mail: ulfbuentgen@gmx.de*

[2] *Tree-Ring Laboratory, LDEO, New York, USA ; e-mail: dfrank@ldeo.columbia.edu*

[3] *Swiss Federal Research Institute WSL, Birmensdorf, Switzerland ; e-mail: esper@wsl.ch*

Motivation

Briffa *et al*. (1998) describe a reduced sensitivity of recent tree growth to temperature at Northern Hemisphere (NH) high latitudes. Their study shows a divergence starting about 1950 between increasing mean summer temperature and decreasing tree-ring density and ring width for North America and several regions of northern Eurasia. This phenomenon is significant, because it questions the validity of ring-width and density records as being a proxy for mid-to-low frequency temperature variability. We believe that a detailed view of the instrumental records of northern Eurasia will improve our insight in this matter.

Here we analyze the sparse set of meteorological records available for northern Eurasia by subdividing the area North of 65°N into four study regions: North Europe, West Siberia, Central Siberia, and East Siberia. For these regions, we analyzed the raw instrumental data and the adjustments made to these measurements by the Global Historical Climatology Network (GHCN). In particular, we investigated what urban adjustments should be made after the completion of all other station corrections and adjustments. Corrections done for urban warming were of particular interest to us, because rising temperature trends can in part be forced by warming effects of urbanized territories. Our assumption was that the discrepancy between the instrumental and tree-ring data might be caused by corrections that do not adequately or fully remove the urban warming effect.

Introduction

The large number of tree-ring sites in the NH, especially in the boreal zone near the northern timberline, provides a valuable network for the reconstruction of paleoclimate (Schweingruber 2002). Tree-ring chronologies can be used as a proxy for past summer temperature, because both the density of the wood formed during the late summer as well as ring width correlate well with local temperatures during the growing season, especially with temperatures in June, July and August (Briffa et al. 1998). Tree-ring chronologies therefore can provide a detailed history of changing temperatures throughout the last millennium, on local, regional and even hemispheric scales. However, the reconstruction of paleoclimate by using proxy data such as tree-rings is closely tied to temperature observations, because the proxy must be calibrated against climate data in order to estimate the magnitude of past temperature changes.

Briffa *et al.* (1998) describe a reduced sensitivity of recent tree growth to temperature, showing decadally smoothed maximum-latewood density and ring-width series together with mean summer temperatures recorded by a sparse instrumental meteorological network. They show that around 1950 a divergence started between the tree-ring data and temperature, expressed by a slightly increasing mean summer air temperature and decreasing tree-ring density and ring-width values. They scaled all data series over the period 1881-1940 to have zero mean and uniform variance, except for East Siberia where the interval 1932-1975 was used due to a lack of older instrumental records.
Raw measurements on meteorological phenomena (e.g. temperature, precipitation) must be individually adjusted in order to account for problems such as shifts in station locations, changes in instrumentation and urban heating influencing the station's environment. Such corrections are made by the GHCN (Peterson et al. 1998, 1999). In this paper, we analyze the adjustments made to the raw instrumental data from Northern Eurasia used by Briffa *et al.,* in order to come to a better understanding of the signal in these time series caused by urbanization effects (Jones et al. 1990). One hypothesis is that some of the divergence in the low-frequency relationship between the tree-ring and meteorological records as seen in Briffa et al. (1998), is caused by the fact that effects of urban warming were not properly or fully removed from the instrumental measurements.

Material and Methods

In order to get a detailed view on instrumental meteorological stations in the large region of northern Eurasia between 65°-75°N, we downloaded both raw and adjusted version 2 GHCN monthly weather station temperature data from the IRI/LDEO Climate Data Library website. Version 2 of the Global Historical Climatology Network is a data set of 7300 monthly mean temperature stations and 5100 monthly mean maximum and minimum temperature stations, gathered from 30 data sources (Peterson et al. 1998). In order to be consistent and clear, we only used the homogeneous raw and adjusted data series that were marked with „ver.0“ and did not mix different sources.
After downloading the data from all 23 stations in our study area that had data for at least the period 1950-1980, we classified them by the length of their records and by their surrounding population (Figure 1). Seven stations supplied records that start before 1900, five of which are located in Northern Europe and West Siberia, and only two of which are situated in the vast expanse of Central and East Siberia. Following GISS (Goddard Institute for Space Studies) conventions, the 23 instrumental meteorological stations were classified as urban (pop. > 50,000), suburban (pop. > 10,000) and rural (pop. < 10,000) (Hansen et al. 1999, 2001).

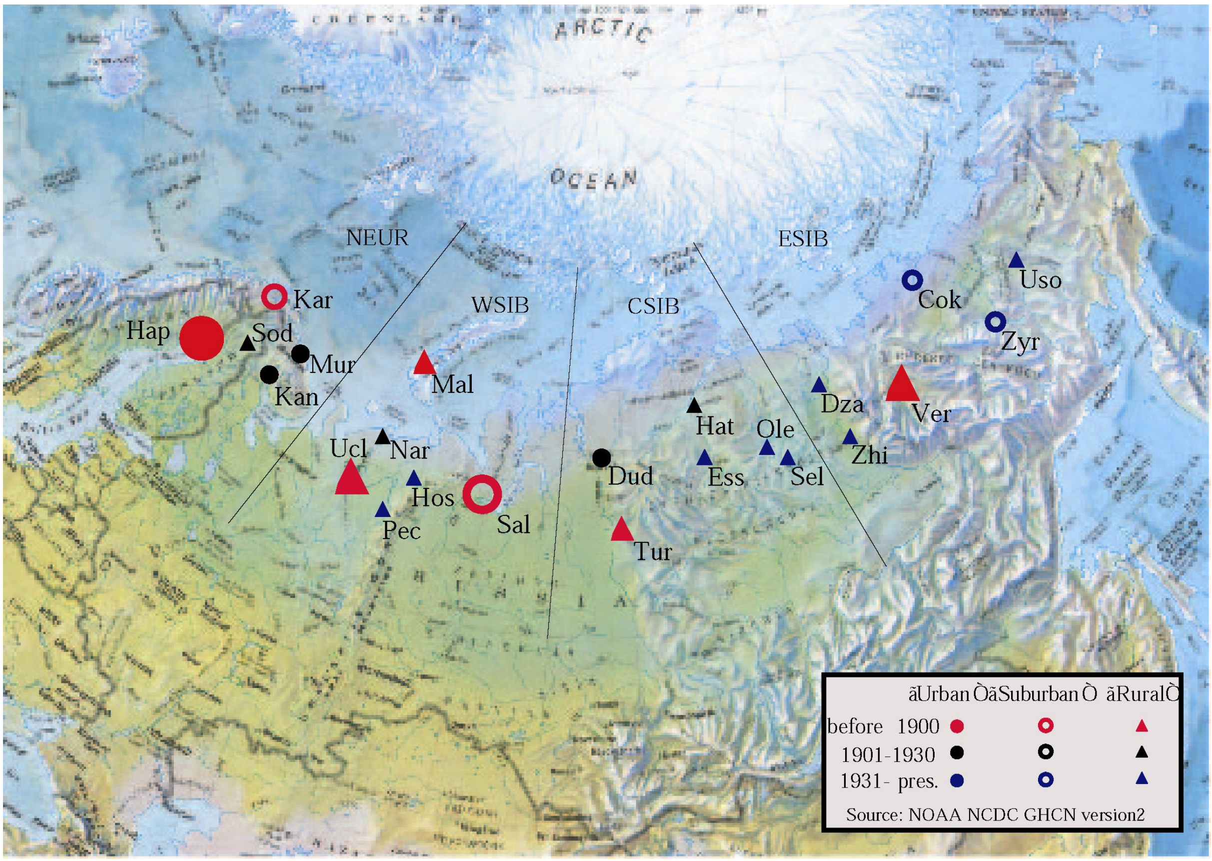

Figure 1: Locations of the 23 meteorological stations used in our study. These stations were classified according to the length of record and population setting. The four sub-regions are also shown: NEUR=Northern Europe; WSIB=Western Siberia; CSIB=Central Siberia; ESIB=Eastern Siberia.

The large size of the study area near the northern timberline prevents us from handling it as a single region. Based on station correlation matrices for the raw and adjusted data series, the 23 stations were subdivided into 4 geographical regions: northern Europe; West Siberia; Central Siberia and East Siberia. These four regions are similar to the division of Eurasia by Briffa *et al.* (1998). For northern Europe, in addition to the records from Russian meteorological stations, we also obtained records from Sweden – Haparanda, the longest record measuring since 1875 – Norway, Karasjok – and Finland, Sodankyla.

Figure 2 shows the raw and adjusted normalized June, July and August temperature trends of the individual stations, as well as the regional average trend curves, for each of the 4 regions (Figure 2). All data were normalized over the period 1951 – 1980, because all meteorological series cover this 30-year interval. The normalization was done to avoid the dominance of a single month when averaging monthly temperature records. We also normalized various stations over their entire individual length. In these cases, we obtained similar temperature trends and relationships between the raw and adjusted series. This implies that most likely no bias was introduced by using an interval of 30 years only.

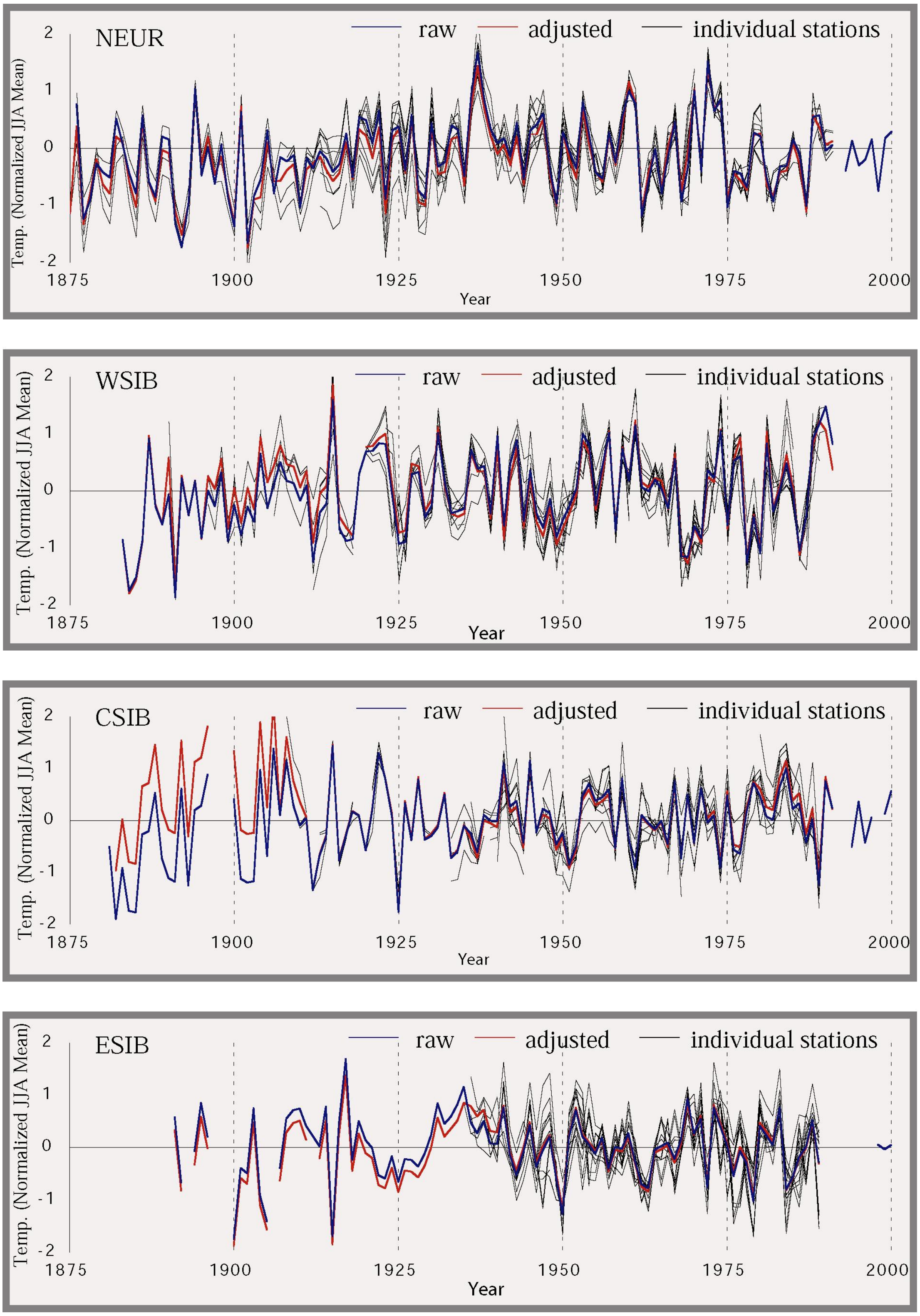

Figure 2: Plots of raw and adjusted normalized JJA mean temperatures for the four subregions. NEUR=Northern Europe; WSIB=Western Siberia; CSIB=Central Siberia; ESIB=Eastern Siberia. Individual station records (thin black lines), and regional means for both the raw (thick blue lines) and adjusted (thick red lines) are shown.

For each station record, we calculated the difference between the adjusted and raw summer temperature, in order to reach a more precise understanding of the way the GHCN adjusts raw data. We did not use the normalized data to show real adjustments in C°. Figure 3 shows the adjusted minus raw data for the four stations classified as urban in our study area.

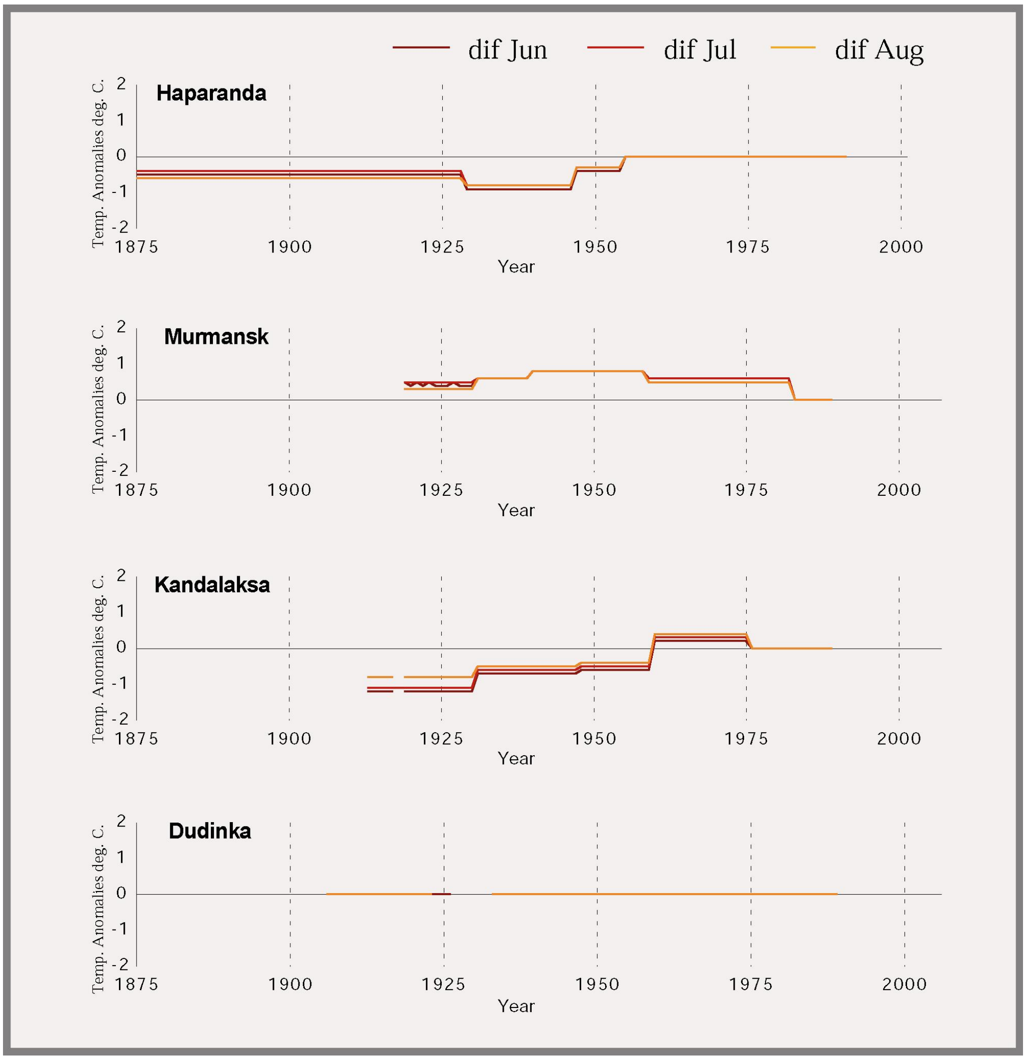

Figure 3: Adjusted minus raw values for the months of June, July and August for each of the four urban stations in the study area. In the absence of other factors, adjustments for urban warming would result in lines of negative slope when differences are calculated in this way. No adjustments were made to the summer Dudinka record.

Discussion

Gridded meteorological data represent weighted averages of varying numbers of station records. When analyzing gridded temperature data in data-sparse regions, one single station can have a huge impact on a large area. Figure 1 shows that in the high northern latitudes of Eurasia both the length of the meteorological records as well as the density of the spatial distribution of the meteorological stations decrease from West to East (only three meteorological stations in the region of 65° - 75°N reach back to 1881). This implies that the findings based on these data have to be viewed with some caution.

Plots of the normalized individual raw and adjusted series, and their means (Figure 2) for the four regions, do not reveal a consistent or clear relationship between raw and adjusted series. The means of the adjusted and raw series are fairly similar, except towards the earlier parts of the instrumental record, where significant differences occur. The earlier intervals are covered by fewer data series, which makes their average series sensitive to adjustments made to individual stations. This early portion of the record is critical for the understanding of the lower-frequency trends in the instrumental records during the late 19th and 20th centuries. It also further illustrates the limited nature of the available instrumental data.

Similarly, differences between raw and adjusted series for the four urban stations do not reveal consistent results (Figure 3). If the series had been adjusted to correct for urban warming, we would expect to see a negative slope for the adjusted minus raw data. However, trend lines for the Haparanda and Kandalaksa stations yield positive slopes. No adjustments were made to the Dudinka station summer temperatures. Only the Murmansk station indicates a general downward correction. These results either suggest a dominance of other corrections that mask those done for urban warming, or they may simply indicate the ommission of adequate corrections accounting for urban warming. Similar graphs for all stations (not shown) also do not reflect corrections for urban warming independent of their surrounding population. We could not detect any uniform adjustment pattern based on the three population classifications (Urban, Suburban and Rural) that is related to the individual size of the settlement where the meteorological station is located.

In summary, when focusing on the way the GHCN adjusts raw instrumental data, no intuitive adjustments were found that might relate to the elimination of urban-warming effects. We conclude that the current view of the 'true' climate of northern Eurasia to some extent is uncertain, due to (a) the sparse distribution of meteorological stations between 65°N and 75°N, (b) the general and rigid classification (urban, suburban, and rural), and (c) the manner in which adjustments to the meteorological data were performed or ommitted. Potentially, some of the low-frequency divergence between tree ring and instrumental data can be explained by inadequate or missing corrections. We plan to further analyze the discrepancy between the tree-ring and instrumental records in the northern Eurasian sector.

References

Briffa KR, Schweingruber FH, Jones PD, Osborn TJ, Shiyatov SG, Vaganov EA, 1998. Reduced sensitivity of recent tree-growth to temperature at high northern latitudes. Nature, 391: 678-681.

Hansen J, Ruedy R, Glascoe J, Sato M 2001: GISS analysis of surface temperature change. Journal of Geophysical Research, 104: 30997-31022.

Hansen, J, Ruedy R, Sato M, Imhoff M, Lawrence W, Easterling D, Peterson T, Karl T, 2001. A closer look at United States and global surface temperature change. Journal of Geophysical Research, 106: 23947-23963.

Jones PD, Groisman PY, Coughlan M, Plummer N, Wang WC, Karl TR, 1990. Assessment of urbanization effects in time series of surface air temperature over land. Nature 347, 169-172.

Kahl JD, Charlevoix DJ, Zaitseva NA, Schnell RC, Serreze MC, 1993. Absence of evidence for greenhouse warming over the Arctic Ocean in the past 40 years. Nature, 361: 335-337.

Peterson TC, Vose R, Schmoyer R, Razuvaev V 1998: Global Historical Climatology Network (GHCN) quality control of monthly temperature data. Int. J. Climatology, 18: 1169-1179.

Peterson TC, Gallo KP, Lawrimore J, Owen TW, Huang A, McKittrick DA 1999: Global rural temperature trends. Geophys. Res. Lett. 26, 329-332.

Schweingruber FH 2002. Jahrringforschung und Klimawandel in den borealen Wäldern. Schweiz. Z. Forstwes., 153: 29-32.